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(54) Ultrasonic gas composition measurement

(57) Conventional gas meters measure volumetric flow rate whereas the heat energy of the gas flowing varies with the temperature and pressure and with the relative proportions of hydrogen and methane in the gas supply. The invention provides a heat energy flowmeter comprising means for measuring mass flow rate in conjunction with apparatus for measuring the relative amounts of hydrogen and methane in the mixture. The latter is uniquely related to the velocity of the sound in the gas and the temperature of the gas, and ultrasonic time-of-flight transducers 1, 2 and temperature transducer 10 provide the values from which the relative amounts can be measured. The apparatus may be used without the mass flowmeter and for other gases. The transducers 1, 2 are switched to each act successively as transmitter and receiver, and a timing circuit 7 calculates the signal velocity in each direction and this is averaged in a store 8. A processor 9, which also receives a temperature value and a mass flow rate value, infers the relative proportion of the gases and hence the energy flow rate.

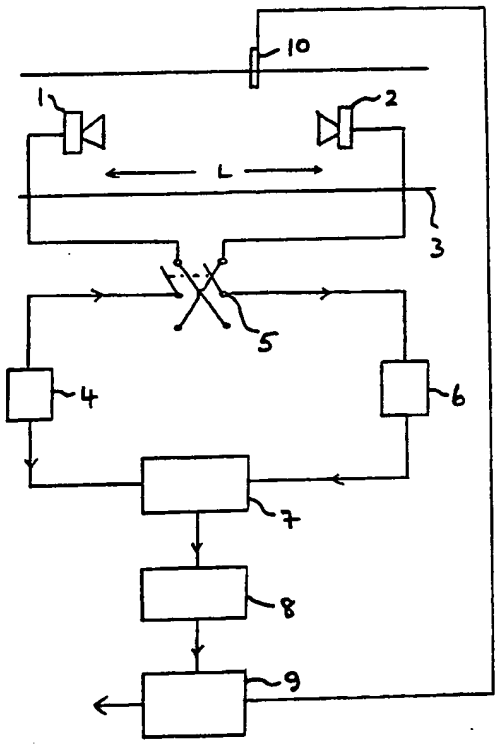

Fig 1.

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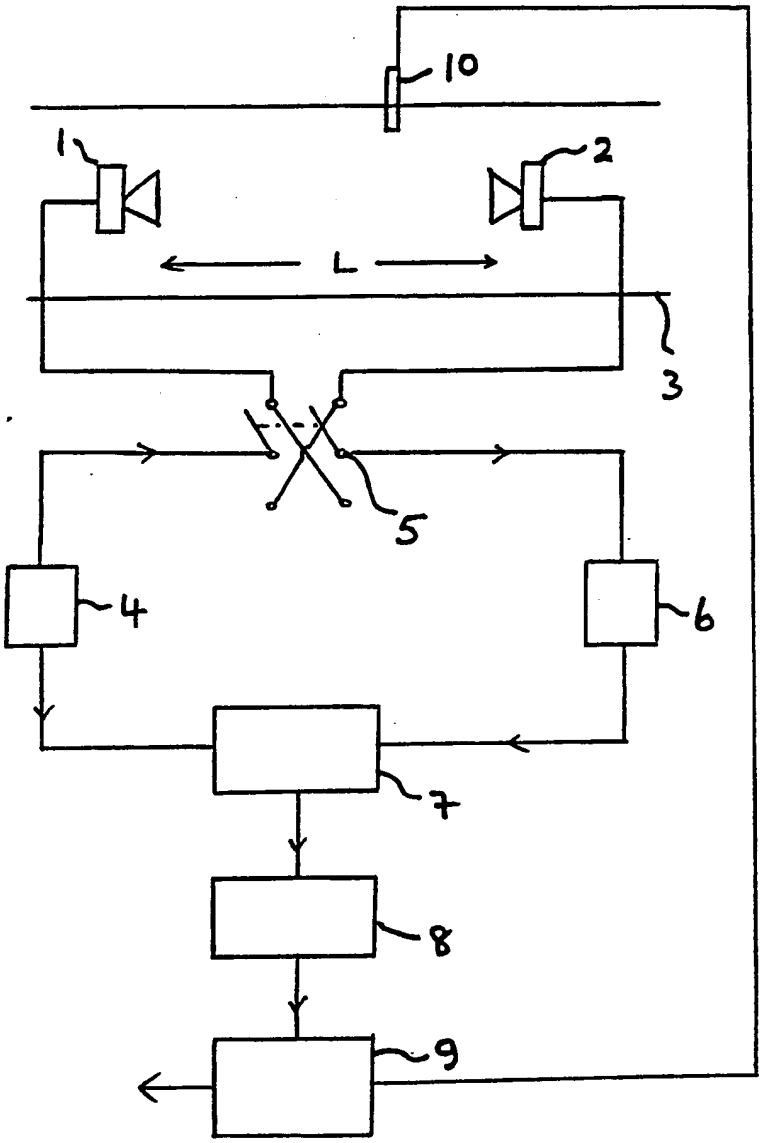

Fig 1.

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Measuring Apparatus

This invention relates to measuring apparatus in general, mass flowmeters in particular, especially those which function as domestic gas meters.

Conventional gas meters measure the volumetric rate of flow, but this only approximates to the heat energy consumed since the heat output at a given volume depends on the temperature and pressure e.g. on a cold day gas is more dense and a given volume would therefore produce more heat.

Mass flow rate would give a more accurate indication of the heat output of the gas, but problems are still caused since natural gas, which forms the basis of the UK gas supply system, consists of a mixture of two components, namely, hydrogen and methane, and any variation in the relative proportions of these causes a variation in the heat output but not a corresponding change in the mass flow rate.

The invention provides apparatus for obtaining a measure of the relative amounts of two components in a gaseous mixture of the two components, which comprises a sensor for sensing the velocity of sound in the gaseous mixture, and means for obtaining the value for the relative amounts of those components that is appropriate to that velocity.

The acoustic velocity in the gaseous mixture is used as the basis for determining the relative amounts by mass of the two components. The apparatus may be used as part of a heat energy flowmeter comprising means for measuring the mass flow rate of the gaseous mixture and means for obtaining the heat energy of the metered gas from the mass flow rate and the relative proportions of the components in the gaseous mixture. The invention therefore enables a domestic gas meter to be produced which gives readings of the heat energy consumed which are independent of temperature, pressure and variations in the relative quantities of hydrogen and methane in the gas supply.

Advantageously, the means for obtaining the said value is arranged to obtain it by reference to stored values which correlate the variation in velocity of sound in the gaseous mixture with the relative amounts of each component. Preferably, the apparatus also includes a temperature sensor and the means for obtaining the value is arranged to correct that value produced for the temperature.

The velocity sensor may comprise an ultrasonic transducer and an ultrasonic receiver, together with means to calculate the acoustic velocity from the time taken for a signal to propagate between transmitter and receiver and the distance therebetween.

The invention also provides a method for obtaining a

measure of the relative amounts of two components in a gaseous mixture of two components which comprises measuring the velocity of sound in the gas and using this value to obtain the relative proportions of the two components appropriate to that velocity.

A heat energy meter constructed in accordance with the invention will now be described by way of example with reference to the accompanying drawing which is a schematic view of the apparatus.

The flowmeter is a domestic gas meter which meters the heat energy i.e. the calorific value of the gas flowing. The flowmeter consists of a mass flowmeter (not illustrated, but which may be of the form described in our co-pending patent application No. 8720341), and an apparatus to obtain a measure of the relative amounts of methane and hydrogen in the gas supply.

Domestic gas i.e. natural gas consists of almost entirely of hydrogen and methane, but there are certain variations in the relative proportions of these components in the mixture supplied to consumers. Thus, in order to measure the calorific value of the gas supplied, as well as knowing the mass flow rate, it is also necessary to know the relative proportions of hydrogen and methane.

The invention makes use of the following equation

$V = \sqrt{\frac{\gamma RT}{M}}$, where

V is the acoustic velocity,

γ is the ratio of the specfic heat of the gas at constant pressure to the specific heat at constant volume,

R is the universal gas constant,

T is the absolute temperature,

M is the average molecular mass of the gas molecules.

For a given temperature, V gives a measure of $\sqrt{\frac{\gamma}{M}}$.

The invention also makes use of the fact that γ for methane differs markedly that for hydrogen e.g. γ = 1.41 for pure hydrogen and = 1.31 for pure methane, and has an intermediate value for mixtures of hydrogen and methane. Consequently, a measurement of V at a given temperature also gives a measure of the relative proportion of hydrogen and methane in the mixture.

A knowledge of the relative proportion of hydrogen and methane together with the mass flow rate enables the true calorific value of the gas to be metered.

Referring to Figure 1, the acoustic velocity is determined in the following way. Ultrasonic transducers 1, 2 are positioned in a gas pipe 3 and are driven by electronic signals, either continuous or bursts, from a transmitter 4. Depending on the position of reversing switch 5, only one transducer transmits at any one time and the signal is received by the other, and converted to an electronic signal and passed to the reciever 6.

A timing circuit 7 receives the electronic signals from both transmitter 5 and receiver 7 and calculates time

difference between the two, and then calculates the velocity of the acoustic ultrasonic signal taking into account the distance L between the ultrasonic transducers 1, 2. However, the ultrasonic signals are propagating parallel to the axis of the gas flow and so are slightly speeded up or slowed down by the flow of gas itself. For this reason, store 8 averages successive values of the velocities obtained by repeatedly changing over the reversing switch 5. The average of the velocities measured against flow and with flow cancel out the effect of the flow so that the acoustic velocity measurement is independent of the flow velocity.

The output of the store 8 is fed to processor 9, which also has an input from the temperature sensor 10 in the pipe. The processor contains in a store values of the acoustic velocity at a series of given temperatures and corresponding values, experimental or calculated, for the relative proportion of hydrogen and methane in the mixture. Accordingly, the processor is able to infer a value of the relative proportion of hydrogen and methane appropriate to the acoustic velocity and temperature measured.

The processor also has an input from a meter for determining mass flow rate. From further stores containing values of the energy content per kilogram (a quantity which is related to calorific value) for a series

of different proportions of hydrogen and methane, the processor produces a value for the energy content per kilogram for the particular mixture passing along the pipe and, multiplying this by the mass flow rate, calculates the energy flow rate.

If desired, the processor may contain values corresponding to different constituents of gas in order that the gas meter can be used for supplies other than of natural gas, operable by appropriate switches, or the processor may include switches to revert to mass flow sensing only.

Any type of velocity sensor may be used e.g. that disclosed in our co-pending patent application No. 8720341.

Equally, the mass flowmeter may be omitted, in which case the apparatus can be used just to determine the relative proportions of two non- reactive components in a gaseous mixture, for which γ for the two components differs.

CLAIMS

1. Apparatus for obtaining a measure of the relative amounts of two components in a gaseous mixture of two components, which comprises a sensor for sensing the velocity of sound in the mixture, and means for obtaining a value for the relative amounts of the two components corresponding to that velocity.

2. Apparatus as claimed in claim 1, in which the means for obtaining the said value is arranged to obtain the value by reference to stored values correlating velocity of sound in the mixture and the relative amounts of each component.

3. Apparatus as claimed in claim 1 or claim 2, in which there is provided a temperature sensor, and the means for obtaining the said value is arranged to correct the value produced for the temperature.

4. Apparatus as claimed in any one of claims 1 to 3, in which the velocity sensor comprises an ultrasonic transmitter and an ultrasonic receiver, and means for calculating the velocity from the separation between the transmitter and the receiver and the time taken for the ultrasonic signal to pass between transmitter and receiver.

5. Apparatus as claimed in any one of claims 1 to 4, in which the apparatus is arranged to obtain a measure of the relative amounts of hydrogen and methane in a mixture of

hydrogen and methane.

6. Apparatus for obtaining a measure of the relative amounts of the two components in a gaseous mixture of the two components, substantially as herein described with reference to the accompanying drawing.

7. A heat energy flowmeter for measuring heat energy of a gas flowing along a path, which comprises apparatus as claimed in any one of claims 1 to 6, in combination with means for measuring the mass flow rate.

8. A heat energy flowmeter as claimed in claim 7, in which the flowmeter is a domestic gas meter.

9. A method for obtaining a measure of the relative amounts of two components in gaseous mixture of the two components which comprises sensing the velocity of sound in the gas, and obtaining a value for the relative amounts of the two components corresponding to that velocity.

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